// THE VIRGINIA TEACHER

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WHAT ABOUT JUNIOR HIGH SCHOOL SCIENCE?

EACH human generation seems to have its wonders, which surpass the things of common experience. We build higher buildings, deeper and longer tunnels, fly higher, farther, or for a longer time in the air. We cause chemistry, biology, or physics to do things which were recently called impossible. We see so far into space that we make our own earth almost nothing in the space it occupies, yet it is the home for the minds which learn such wonderful things. Man is a daring and adventurous animal, always wanting to try something which no one before has succeeded in doing, and always wanting to know what no one has yet learned. He is restless in the presence of things achieved, anxious always to carry his flashlight of experimentation and investigation into unexplored and dark places so that light and knowledge may dispel darkness and ignorance. He is always wanting to push back the borders of the unknown. Man's inquiring and daring mind is in itself a scientific fact of the greatest significance.

For more than a year those who can have visited the site of the New York-New Jersey-Hudson River Bridge, and such visits may be made for two years before the time of proposed completion of this spectacular structure. Foundations were laid deep below the water level in the solid, ancient rock. Cemented masonry reinforced by steel was built by men who went deep into the caissons which held the water back. Then two steel towers, one for each end of the future bridge, slowly began to rise until a height was reached 635 feet above the water of the river, a height exceeding the Washington Monument and making the height if not the behavior of Niagara Falls seem commonplace. So accurately had calculations been made and so carefully had construction work been done that the tops of the finished towers which are to support the 3500 feet of free-swinging bridge came within two-and-a-half inches of the original calculations and designs, which were made before any construction work was begun. A discrepancy of two-and-a-half inches, however, causes embarrassment to a mathematical engineer. Then the first steel cables, which had been tested in all details, were raised from the river and stretched from tower to tower. As weeks passed, these first cables were joined by others. Finally, the floor of the workers' footbridge, the so-called "cat walk," began to be appended to the temporary cables. Cages carrying workmen and materials moved slowly from the towers along the cables to a point midway between the towers and above the river, and waited in high suspension while a section of the cat walk was constructed at that dizzy height. The cages then returned for more material, repeating this journey throughout a three-week period. Men crawled along the cables, fastened sections of the temporary floor with rivets, hammered them into their proper places, then slid back to the relative security of the hanging cage or to a bit of finished floor of the cat walk. A whistling workman hanging over the edge of a moving section of the outermost part of a growing footbridge, suspended several hundred feet in the air by a few cable wires, holding to what seems from the distance to be almost nothing, reaching forward his full length to

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fasten the section on which he is riding to a part of the cable not yet reached by any foothold—he is a man of courage and self-control, engaged in one of the stupendous achievements of modern science. Each day, as the bridge grows, one's respect for modern knowledge grows, as does one's appreciation of man's intellectual and physical courage.

It takes the work of many scientists to plan and produce such a structure as the New York-New Jersey-Hudson River Bridge. Students of economic and social needs analyzed the situations, proved the need, and selected the site. Geologists studied and described the undersurface conditions to a depth of three hundred feet. Surveyors established the exact locations and relations. Engineers of many kinds planned and mathematicians calculated the materials to be used. Physicists, chemists, and biologists contributed knowledge of materials, of processes, of human relations and needs. Architects designed the structure, assembled the needed knowledge, and convinced authorities that the bridge could be built. Economists estimated the human services that would probably result and guided the financing of the giant enterprise, estimated to cost sixty million dollars. It is expected that when opened in 1932 the world's greatest bridge, in the first year of its operation, will care for the passage of not less than twenty million people.

Such achievements of modern science as that cited seem to be expected nowadays. The Zeppelin flies around the earth in a few days, making four stops en route. The inimitable Lindbergh does a new "impossible" thing every once in a while. The chemist proves that hydrogen is a compound and not the elemental substance so long regarded as one of the fundamental ideas of matter. The physicist discovers waves by means of which ideas are so readily transmitted that Byrd in the frigid antarctic talks easily with his friends and family on their hottest July day; and when we tell Byrd about our winter, he replies that the oncoming antarctic summer is his time for opening his fascinating and long-hoped-for explorations. The biologist produces foods in such abundance and of such fine quality that the food markets are overstocked, and a few of the more favored members of human society instead of being hungry are trying to keep their weight down. Our ancestors crossed the continent with great exertion, often in hunger. Today men may cross in comfortable palace cars, with food dangerously abundant, and an added danger from lack of exercise.

This wonder, after all, is not primarily in the material achievements which benefit men, great as that is. The greatest wonder is the active mind of man, always discovering and inventing new things in the fields of knowledge. Problems are solved by man's use of scientific knowledge. One great bridge when completed becomes the lesson learned, by means of which new problems are met, new lessons learned, that is, new bridges constructed. Creative achievements follow wherever science is carefully studied, and wherever scientific imagination is aroused. Communities and nations gain in material benefits, but more in growth of ideas wherever they take science study seriously. The real wonders are the increasing knowledge and daring, the knowledge-guided courage and adventure in using what is known as a means of adding new achievements.

It is knowledge of science, its ideals and its realism, not merely possession of bridges, airplanes, and huge stores of the finest foods, that is needed by the generation now rapidly becoming "the next generation." The gains by means of science are for those who learn to know science, to control scientific appliances, and to act as truth indicates that one should act. A runaway automobile is an evidence of someone's ignorance or lack of proper use of science knowledge. Do not some people possess automobiles who have little real need for going anywhere? An outbreak of typhoid, smallpox, or diphtheria is evidence of harmful ignorance. Is possession of a radio always an indication of benefits to be derived through its use? Living truly in a modern science age depends upon more than merely being alive during the period of science's greatest achievements. The general science course tries to help young people to know some of the more important aspects of modern science, and hopes to start them toward a sound belief in truth as a safe way of living.

I. *Where did the General Science Course come from?* Let us take a rather prolonged look at the educational program of introducing pupils to the study of science. There are those who think that the general science course was devised by a score, more or less, of inventive and restless science teachers who wished to change the existing order of things, and who after casting about for fertile fields of operation chose the introductory science course as the field in which to operate. Such conclusions are quite in error. Fundamental tendencies and considerations in science teaching were in operation and would have produced a changed type of introductory science course even if none of those who have written about the course had taken any hand in it. Persons do help in producing advances, but advances are so much bigger and more comprehensive than persons that they occur as movements into which individuals fit as causal incidents. A new type of introductory science course was in process of development long before anyone thought of the term "general science."

The development of new types of junior-high-school science courses was caused by several factors. The four chief factors are the movement for universal education which brought about changes in the purposes of public education; certain principles of psychology and of learning which had not previously been recognized; the widespread dissatisfaction resulting from the use of highly specialized science courses as an introduction to science study; the positive results secured from experimental work which was designed to produce a more effective foundation in science knowledge, interests, and attitudes for the uses of the average citizen. These four factors will be discussed first in the following paragraphs.

In all school systems until a few decades ago (and still in some systems) the elementary-school period, consisting usually of eight school years though sometimes of seven years, was regarded as a period of schooling designed to train in the so-called tool subjects—reading, writing, spelling, arithmetic, geography, and American history. To these subjects others were sometimes added, but little or no effort was made in the elementary schools to teach the more logical and more scholarly organized special subjects. Those pupils who went beyond the elementary schools necessarily engaged in academic study, that is, as the name implies, in the study of those subjects which had composed the program of the older academy. The academy or academic studies had been developed into a program designed to precede college studies and, to some extent, to assist in carrying on those studies in later college years. Also, as the academic, or secondary, work improved in quality, there was a tendency for certain college subjects to find their way into the upper years of the academy or high school. Then, all through the decades there have been recurring demands that there shall be introduced into the curriculum more and more material knowledge which people can use in the world of affairs. In a democracy such as ours there always has been a constant demand that education shall help people in the day's work as well as in scholarly pursuits. Education surely should help people to do better the kinds of work which their lives bring to them.

Furthermore, increasing numbers of people became ambitious and able to send their children to school beyond the elementary-school years. The commonwealth grew in its appreciation of the fact that education is essential to good citizenship. Laws for compulsory education were passed, requiring a period of schooling beyond the elementary school for all pupils who are not retarded in progress. At present every state in the Union and the District of Columbia have a law requiring school attendance. Of all the states of the Union six require school attendance until fourteen years of age, two until fifteen, thirty-one until sixteen, five until seventeen, and five until eighteen. The compulsory school-attendance laws seem to have been passed by legislatures without much consideration of whether school programs have been developed that will surely be most useful to the increased hordes of school pupils. In America we believe in education for everybody, but often we are not quite clear as to what it is that education is to do for everybody. Everyone must have it, whatever it is. Our national enthusiasm for education may be said to be universal and general, but not specific. Several movements are now in progress, looking toward better conceptions of just what this increased time expenditure in education should specifically secure. And we now soon learn that not all should remain in school so long as now required by law.

One type of consideration pertains directly to science as a factor and as an agency in universal education. In a true sense it may be said that to some extent all live in and by modern science. We cannot choose to omit it wholly, even if we would, since it has become incorporated into almost all we think and do. No recital of one's daily uses of science is necessary. Each one may produce for himself convincing proof of the inescapability of modern science. It is rather a question of whether it will be adequately understood and whether it will be controlled for worthy purposes. If science is to be understood and controlled for worthy purposes it would seem to follow that the citizens' science education should deal with those considerations and manifestations which are within his experience, not with science unrelated, abstract, and unexperienced. Thus universal education, which in period of years averages well through the junior-high-school years, would seem to demand a kind of science education in this period which shall make definite contribution to the life of the average citizen. That, therefore, is one of the major purposes of the general science course.

Certain psychological considerations helped to produce the general science course. In former times when physics, biology, or physiography was used as an introductory science course, the details, the terminology, and ever-present analysis were taught first, with the expectation that they would later fall into proper relations as the whole subject began to be appreciated. The pupil was expected to learn to measure accurately, and it was assumed that he would later have problems which would require use of his facility in accurate measurement. First he would dress himself, so to speak, with an equipment of measuring devices, then would go out to find his problem. He would learn the meaning of the terms to be applied to the divisions and processes of a science subject in order that this knowledge would be available when the logically arranged subject should later be studied. The whole theory of such teaching might be expressed as follows: first, learn details and terminology and acquire the kinds of technique and accuracy needed in the subject; then later, as the study is followed, there will come needs for these initial acquisitions. Such a theory ignored the fact that young pupils, like most older people when in a new field of study, first see and sense large units, and then later acquire details as needed, to help in the further understanding of the large unit. For example, anyone can see and appreciate the service rendered by an airplane, and most young people are interested in learning something about airplane wings and supports, driving and guiding mechanisms, and devices for maintaining balance; but only advanced study can properly deal with preferred types of ignition, with fuel tests, with qualities of steel, wood, and glass, or with detailed study of air mechanics and temperatures. Or, any young pupil may readily sense the general processes and results of the manufacture of food by green plants, and may come to think of fields of wheat and corn as man's controlled devices for causing green plants to do more food-making than they would do if growing wild. But to introduce young students to this unit of work by having them study details of leaf and stem anatomy and by explaining the intricate chemical reactions of food-making, confuses their minds with details which can take on meaning only after the larger significance of structure and functions has been acquired. Young students can see and appreciate hills, valleys, and stream flow, but to begin by exact measurement of where the hill stops and the valley begins, or by measuring the gradient of stream flow, is a "logical" and meaningless, but is not a psychological and meaningful beginning.

Therefore the introductory science course consists of large and significant units of work into which as much detail and exactness is introduced as are needed for major understandings. When the later and the more detailed studies are made, the new learning falls into its proper place in the large units with which the science study began. Thus the general science course is composed of large units of science knowledge of the kinds needed in the lives of most citizens. These units use materials from any special field of science. They build a foundation in the science that is common to life experiences. If any further courses in science are studied later, they are built where they should be, that is, upon this foundation, as the upper story of a building rests upon its foundation. Indeed, the more specialized science subjects may rise through several levels, each rising higher and becoming more specialized in its nature as the student's education continues.

In the years preceding the first efforts to teach a course in general science, various special sciences in one school or another were used as the introductory course. In none of these was there any adequate foundation of those general topics of science which would allow the student to gain an initial notion of the meaning of science. The upper stories of the house were being built without foundation, without adequate entrance ways—with windows for looking out, but with no doors for young people to enter by. General dissatisfaction resulted. The specialist authorities sometimes said the trouble was that the work was not exact enough, that not enough laboratory work was done, and that time enough was not allowed; they even said sometimes that the pupil should learn to recite principles first, and then go about to make applications of them, thus reversing the order of learning. So laboratory periods were doubled and more notebook-making was added, and more memorizing for examinations was done; but dissatisfaction increased. Then, in some of the special science courses, introductory and foundation materials were introduced. For example, physiography included topics from plant, animal, and human life, from chemistry and physics, and in some schools the first-year science time was divided between general physiography, human physiology, and hygiene. Also, the biology course when taught in the first year, instead of beginning with biological topics, began with topics in chemistry and physics which helped in understanding biology; and throughout the course in biology there now appeared abundant topics related to human physiology and hygiene. Thus general topics began to find their way into specialized subjects.

These tendencies of the special science courses to become general when they were used as the introductory science work preceded the formation of an introductory general science course. In their attempted purposes and to some extent in their efforts to include subject matter from other sciences, these courses were stages in the development of the general science course. The next step was taken when larger topics or units of science were organized with subject matter taken from any science as it was needed in the purposeful study of the topic.

Experimentation with different types of topically organized introductory science began in independent ways in a score or more of schools in various parts of the country. All had a common purpose, that is, to teach worth-while and dynamic science to young students so that they would believe in science and in its way of working, and would use science more effectively. Such a course, it was hoped, would interest pupils in further science studies either in school or out, and guide them in selecting those further studies. These experiments were surprisingly successful. No single science course has ever been adopted so widely in so short a time or studied by so many pupils. No science course has ever taken its position so definitely at a given place in the secondary-school program. It has become truly the introductory science course whether in the junior high school or in the first year of the four-year high school.

While the earlier experiments in developing the general science course did not use the same topical contents, the continuing experiments brought the different proposed courses closer and closer together. Indeed, there is some danger that too rigid standardization may result. A recent comprehensive and interesting analysis shows that the units and subtopics of the course are now definitely recognized.[1] This important study also shows that the topics of the course may readily be grouped for pupils of differing abilities, so that all may have the minimum essentials, the average student may add other valuable topics, while still other topics are available for those students who can do the largest amount of work. Such studies give a new and valid guidance to those who are interested in preparing junior-high-school science texts. The day of random guidance is passing and the day of scientific study of science teaching is arriving.

II. *How should the General Science Course be taught?* Those who teach general science should constantly keep in mind that this is general and not technical science. If what is taught is true it is science, even though its technical aspects are omitted. Therefore its topics, its experiments, and its use of environment should be determined by those aspects of science which are generally useful rather than by the needs of subsequent special studies in science. Subsequent studies, if made, will probably benefit and not suffer from the significant foundations taught in general science. It seems likely that subsequent science studies will be best served if they are wholly ignored during the study of general science. One difficulty with some general-science teaching has existed in the teacher's constant thought of one or more of the special sciences while teaching general science. His "malady of total recall" has devitalized his teaching. One must not be a teacher of any special science while he is teaching general science.

Another difficulty with teachers of introductory science is that they sometimes think that only general and indefinite results are

[1]F. D. Curtis, *A Synthesis and Evaluation of Subject-Matter Topics in General Science.* Ginn and Company, 1929.

expected. Because the topics are general it does not follow that definite results are not to be expected. This is a serious mistake, for any teaching to be worthy must produce learning that can be located. There should be quite definite objectives in mind for each unit of instruction, and careful checks should be made to be sure that these objectives have been reached. For this reason the best textbooks now include preliminary questions when beginning a topic to make sure that the pupil and teacher shall have clearly in mind with what the study deals. These questions should be read and discussed to make clear what it is all about. Then, throughout the discussion, guiding thought questions are asked, and at the close of chapters or of groups of chapters different types of specific questions are asked as to the knowledge, attitudes, and thought developed in the study. This should make sure that what was expected to be done has been done. There is a dangerous modern tendency toward the inference that a more meaningful science course suggests a less exacting course. Pupils need to accomplish more, not less, but when the topics studied are filled with meaning it should be easy to accomplish more. Definite instruction and definite check-up should help to insure better quality and quantity of accomplishment.

One major objective is to learn the scientific facts and interpretations which pertain to the use of science in modern life. Each community has weather problems, and these are good topics for study by all. They offer excellent opportunities for observation and experiment: air; air currents; air and water; air and the gases that are always found in it, the gases usually found in it, and those occasionally found in it; air condensation under natural and under mechanical pressures; the rarefaction of air and the production of a partial vacuum; use of air in caisson construction work; purifying air, and pumping air into tunnels and mines, and wherever men work in unusual situations; air in canned foods and in refrigeration; air in homes; air in action as winds—these and many other topics suggest the opportunities for demonstrations, experiments, readings, and discussions about air, which should prove useful and of interest to all citizens.

Manuals and guides for classroom use are provided in abundance for teachers and pupils. These include many specific outlines of demonstrations and experiments for school and home. They deal not only with the topic air, but with all the topics that have been shown to be the essential content of the introductory science course. Some of these guiding outlines are for all pupils in a given class, and some are organized on the plan of contracts for individuals. Most of them provide suggestions for individual-pupil initiative in discovery, or for devising inventive types of experimental work. The publisher of the textbook in use should be asked for these teachers' and pupils' guides for the work in general science. They are usually an organic part of the course.

Each classroom used for introductory science may well accumulate a store of simple illustrative materials. Pupils and teacher can make a good many pieces of simple apparatus. The simpler electrical appliances can be built by pupils with little cost. Glass and rubber tubing, plus a little ingenuity, may result in good working models of pumps, water-supply conduits, and house plumbing. An ice-cream freezer may be a better basis for learning the principles of temperature changes than the most costly apparatus. Aquariums are better apparatus for the study of plants and animals than microscopes, useful as a good microscope sometimes is. Maps, charts, and diagrams accumulated as the result of one class's work are often the beginning of the work of the next class.

There are current magazines which are of great help to the general-science teacher.

The Science News-Letter, published weekly by Science Service, Washington, D. C., is now found in the best high-school libraries, and should be in all. Many pupils, teachers, and citizens receive it regularly. It presents new things in science, things usually so new as not yet to have got into textbooks. It also tells about new books in science, and gives news as to what science men are doing. *Current Science* is a four-page paper published weekly in Columbus, Ohio. It contains many easy and interesting problems in science. *The Science Classroom,* published by the *Popular Science Monthly,* New York City, has articles in each issue by leaders in science-teaching. *The Scientific Monthly,* Lancaster, Pennsylvania, includes longer articles about new and interesting topics in science. Samples are sent of these publications on request, and teachers will find invaluable and fascinating help in one or more of them.

New and interesting books for stimulating and informing reading are constantly being made available. Selected book lists are given in the best texts on science. Long lists are not useful, since the teacher and pupil need books which have been culled from the hordes of available books. A selected list is included here. These were selected by a committee consisting of the writer of this article as chairman, with Dr. Vernon Kellogg and Dr. E. E. Slosson as committee associates. Such lists are always in need of revision, since good new books are constantly appearing. In many leading cities the newspapers now present reviews of the best of the new books on science. If encouraged by pupil and teacher inquiry it is likely that the press would increase its reviews of popular scientific books.

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HIGH SCHOOL SCIENCE SURVEY OF VIRGINIA*

CONTENTS

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1. Introduction

This survey was undertaken primarily to discover the facts regarding high school science instruction in Virginia today. It seemed to be worth while also in this paper to compare present practices in Virginia with those of other states, and to observe the results of recent researches in the teaching of science.

The data for this study were secured from the Annual Report of the Superintendent of Public Instruction of Virginia, 1928-29; from the preliminary reports of the principals of accredited high schools; from the O'Shea Survey Report,[1] and from a science survey questionnaire sent out by the High School Division of the State Board of Education.

The survey questionnaire was sent out to the principals of the 405 accredited high schools in the state, and replies were received from 226.

The data obtained in this survey should prove useful to science teacher-training classes, also to science teachers, superintendents, principals, and others interested in the application of science to various fields in the state, viz., agriculture, medicine, industry, engineering, and hygiene.

The O'Shea Survey Report[2] stated clearly that, in the commission's judgment, much more attention should be paid in the future to instruction in science. The survey staff recognized that in the past emphasis had been placed on history, languages, literature, and related subjects, but that now in a scientific age it is particularly desirable that more emphasis be placed on science courses in all grades of the elementary and high schools. The recent advent of a large number of industries in Virginia makes this all the more necessary.

Since changes in content and method of science instruction can be made wisely only

[1]Report of the Educational Commission of Virginia, by M. V. O'Shea. Richmond, Va., 1928, hereinafter called "O'Shea Survey Report."
[2]*Ibid,* p. 9 and 11.